FRESHWATER BIOLOGICAL ASSOCIATION
F.B.A. Translation (New Series) No. 107

Title: Fish zoning of some watercourses in Normandy

Author: ARRIGNON J.

Reference: Verh.int.Verein.theor.angew.Limnol. 18, 1135 - 1146

Original language: French

Date of publication of original: 1972

Translator: V. A. Wilson

Date of publication of translation: 1977

Number of pages of translation: 11

I INTRODUCTION

The identification of fish zones in western and central Europe has been the objective of the major works of Huet in 1946, 1949 and 1962 and Huet, Lelek, Libosvarsky & Penaz in 1969.

The "fish zones" theoretically give a distribution of types of fish in a watercourse, determined by the application of the "Rule of Gradients" and use of a "Gradients Graph" based on the influence of the current on the distribution of the fish in running water (Huet 1946, 1949).

The mechanical and ecological action of the current is preponderant; it shows directly and indirectly on the speed of the current, on the temperature of the water as well as on the morphodynamic characteristics of the habitat.

Divergences from norm (décalages) are nevertheless recorded (Huet et al. 1969) in particular climatic conditions.

This paper concerns a stream in Normandy specially studied by the author in 1969 and 1970 in the framework of a study on the role of the mean temperature in fish zoning. The study sections were explored following a study trip with M. Huet in 1969.

The paper propounds the comparative study of the morphodynamic and occasionally physico-chemical characteristics, as well as the results of previous sampling by electric fishing of the fish populations of two other streams of the higher Cretaceous layer and supplied by "chalky" water in Normandy and Picardy (Fig. 1).

These examples are extracts of hydrobiological studies carried out by Arrignon on the Levrière from 1965 to 1970 and by Arrignon & Leroy on the Brèche in 1970.

The criteria are as follows:

- The "rule of gradients" applies to those watercourses with some cases of inversion of zones.
- A divergence (décalage) exists between the zoning of streams in Normandy and those in the most northern and eastern regions of Europe.
- The divergence seems due to the influence of the mean water temperature.

II HYDROBIOLOGICAL STUDY OF THE RISLE, NORMANDY

2.0 Physical and morphodynamic characteristics (Fig. 2)

The Risle is 149 km 250 long, rises at 273.100m and enters the Seine Estuary. It is affected by the tides at 16 km 800.

Its source is in the lower Jurassic layer of Le Perche, then crosses higher Cretaceous then Eocene spots (??) (lentilles), to drain into a valley of modern alluvia.

Upstream of its confluence with its principal tributary, the Charentonne (3 m^3/sec), it receives few tributaries, its flow varying from 50 l/sec at 4 km from the source, to 3 m^3 600/sec at the confluence. Downstream it is abundantly fed by three short tributaries, outlets of springs bursting along the bed of the water course.

At the mouth it discharges (42 m^3) 11.230 m^3 (9.100 m^3).

The physico-chemical profile is related to the hydrological conditions above, notably to that which concerns the evolution of the mean temperature and that of the amount of Ca^{++} in the water.

The ecological conditions have been moulded by the presence of 98 weirs for the purpose of providing hydraulic energy for the oldest and "stream" (au fil de l'eau) hydro-electric energy for the others.

The gradient is slight, 4.2‰ upstream to 0.3‰ downstream with two breaks in the gradient which include the appearance of two inversions of fish zones.

2.1 Fish characteristics (Fig. 3)

Table 1 gives the composition of the fish population corresponding to different sectors shown on the length profile of the stream, expressing the physiognomy of its different sections.

If one refers to the theoretical characteristics of the fish zones given by Huet (1962) the Risle has no trout zone but:

a zone superior to grayling in its upper course (gradient 4.2‰)
a zone superior to barbel (gradient 2.5‰)
a zone inferior to barbel (gradient 1.9‰)
a zone inferior to grayling (gradient 3.4‰) at Rugles (inversion)
a bream zone (gradient 1.1‰)
a zone inferior to grayling (gradient 3.4‰) at the Vieille Lyre (inversion)
a zone superior to barbel
a bream zone

Actually the zoning is similar to that shown on the profile:

a trout zone in the upper part
a zone superior to grayling in the middle part (inversion)
a trout zone downstream
a bream zone influenced by the tides

but noting that the downstream trout zone has a tendency to become a grayling zone because of the large number of gravel pits in relation to the stream. These pits become pools for cyprinids and pike: the fish population of the stream tends to evolve.

III Hydrobiological study of the Epte and its tributary, the Levrière, Normandy

3.0 Physical and morphodynamic characteristics (Fig. 4,5)

The Epte is 117 km 200 long, rises at an altitude of 200 m and enters the Seine on the right bank of the river.

The Levrière, a tributary of the Epte on the right bank at 38 km 800 from joining the Seine and at an altitude of 45 m 700, is 25 km 500 long; its source is at an altitude of 120 m.

The principal watercourse successively runs on the higher Jurassic layer and the lower Cretaceous layer of the Pays de Bray fault, then on the base of the higher Cretaceous layer.

Its tributary rises and runs on higher Cretaceous; the nature of its catchment is woodland and pastures.

The system studied includes the Levrière and the Epte from the junction of the two watercourses.

The Levrière receives few important tributaries; its discharge is fed by a succession of springs. It varies from 0.270 m^3/sec at 2 km from the source to 0.840 m^3/sec after receiving the Bonde (0 m^3 360/sec). After its confluence with the Levrière, the Epte discharges 3 m^3 500/sec and about 4 m^3 500/sec at its arrival in the Seine.

The thermal profile of these watercourses is in keeping with the geological, pedological and hydrological conditions. The temperature of the water, like the discharge of the Levrière, has a poor range, contrary to that of the Epte.

The gradient, relatively steep in the upper part of the Levrière (8.5‰) becomes less (1.43‰ at the confluence) and is hardly greater than that of the Epte (1.3‰).

3.1 Fish Characteristics

Table 2 gives the composition of the fish population, corresponding to the various sectors given on the length profile of the stream, expressing the physiognomy of its different sections.

The application of gradient types on fish zoning (Huet 1962) gives:

- a trout zone in the upper part of the Levrière, very rheophilic (8.5‰)
- a zone superior to barbel at 2.200m from the former (gradient 2.5‰). This zone continues downstream from the confluence with the Epte up to the
- last study section (St Clair: width 15 m, gradient 1.3‰).

Actually the zoning is similar to that on the profile:

- a trout zone which covers the whole of the Levrière (at St Paer the trout population represents 55.3% of the whole and, with its population of accompanying fishes: 99.8%)
- a zone superior to barbel, which from the confluence of the Epte and the Levrière, up to Gisancourt (trout 8.4% - cyprinids of running water 40.8% - carnivores 11.6%)
- a zone superior to grayling on 3 km of parts of Guerny (salmonids 41.2% - cyprinids of running water 31.8% - of still water 21.2%)
- A zone inferior to barbel from St Clair (salmonids 3.7%, cyprinids of flowing water 17.6% - of still water 23.7%. Eels (52.5%) considerably influence the fish distribution.

One can consider that the superior to barbel and inferior to barbel zones have a tendency to become a grayling zone because of the success of acclimatisation this introduced species has found in the Guerny section.

The zoning could also be presented as follows:

- a trout zone covering the course of the Levrière
- a grayling zone from the confluence at St Clair

IV HYDROBIOLOGICAL STUDY OF THE BRÈCHE, PICARDY

4.0 The Brèche is 48 km long; it rises at an altitude of 115 m and enters the Oise.

The stream's source is on the Picardian plateau; a plateau constituted of chalk of Campanien at Belemnitella, topped sometimes by Thanetian sand and covered in parts by clay and Sparnacian lignites.

It crosses land recently made of sands and clays subjacent to the coarse limestone of Lutetian (??)

The bed of the stream runs on the limestone from the source to Coiseaux (S.1), then on peat and alluvia up to its confluence with the Oise.

The nature of the catchment is agricultural and grazing upstream, agricultural and marshy at the centre, agricultural and forest, then industrial and urban.

The Brèche only receives one important tributary, the Arré. The stream is fed by a succession of springs, some of which are in the actual bed of the stream, from its original source up to Litz (S.3).

Its flow of 0 m^3 020/sec at the source is 0 m^3 255 at 8 km from there, then greater than that of the Arré, 1 m^3 346 at Clermont (S.4) and about 2m^3 200 at its confluence with the Oise.

The physico-chemical and notably thermal profile is in keeping with the geological, pedological and hydrobiological conditions. The temperature of the water, as the discharge from the Brèche up to the Seravenne (S.5), has a poor range.

The gradient of the stream is poor from its source (2.9‰) at Clermont (S.4 = 2‰) then very poor (1‰ at Rantigny - 0.8‰ at the confluence).

4.1 Fish characteristics

Table 3 gives the composition of the fish population corresponding to various sectors on the length profile of the stream, expressing the topography of its different sections.

An examination of the gradient graph (Huet 1962) would give the following theoretical zoning:

- a zone superior to barbel at 14 km from the source
- a zone inferior to barbel at 11 km (S.3 - 1.2‰ - width 4m 60)
- a zone superior to barbel at 3 km (2‰, width 4 m 60)
- a zone inferior to barbel, then
- a bream zone

The analysis of fish populations leads to the zoning, which is shown on the profile

- a trout zone at 28 km from the source (S.1-S.2-S.3)
- a grayling zone at 5 km S.4-S.5. The salmonid population is important; 99.5 and 99.4%, but it results from stocking. The population of still water fish is natural
- a zone superior to barbel, at 8 km (S.6 - S.7) - the disappearance of trout is due to chronic pollution.
- a bream zone at 4 km from the confluence with the Oise.

V APPLICATION OF THE RULE OF GRADIENTS TO WATERCOURSES FROM HIGHER CRETACEOUS LAYER

From the above, one can draw the following conclusions:

1. that the "rule of gradients" stated by Huet (1946) is applicable to the watercourses of Normandy and Picardy, since the Risle, for example, presents an inversion of zones due in part to a double break of gradient (S.2 = 2.5‰ S.4 = 1.2‰ S.5 = 2.3‰)

2. that the preponderant action of the temperature is perfectly confirmed in the way that Huet (1949) has indicated. "It is above all marked in the watercourses fed by springs coming from limestone, which have a large discharge. In such a situation if a water course with a slight gradient is fed by rheocrenic springs with large discharges, the water remains fresh during the summer along quite a distance and the population is salmonid"

One notes for the Risle, some important deposits (of 100-600 litres/sec) at 5 km (S.5) from a spring of low thermal range (9° in winter, 11° in summer). They in fact make the lower part of this watercourse a salmonid zone. This observation is the same for the Brèche whose course is influenced by subjacent springs in more than 20 km (S.1, 2, 3). When the gradient is slight (2.9‰ - 2.2‰ - 1.2‰) the zone is definitely salmonid. It is a grayling zone only because of the addition of stagnant water (peat bogs and pools). This addition disturbs the constant temperature of the water from springs.

VI GRAPH OF GRADIENTS APPLICABLE TO WATERCOURSES FROM THE HIGHER CRETACEOUS LAYER IN WESTERN EUROPE

The graph of gradients traced by Huet (1962), Huet et al. (1969) does not correspond to any of the situations of the watercourses from higher Cretaceous

layers, whether or not they are influenced by the maritime climate. One notes that the salmonids colonise watercourses with the weakest gradients and highest discharge, except for sections of a width greater than 50 m (Fig 8).

The reason for this particular zoning lies in the preponderant influence of the temperature which is constantly kept fresh (9° - 11°) by springs which are subjacent or close to the watercourses and have a large discharge and low annual range. "Now, the temperature and the discharge to which is related the current speed greatly influence the distribution of fish in running water." Huet 1962, 1969.

In the graph project, the divergence from norm towards the bottom is almost equivalent to a fish zone, but the graph is only approximate: each watercourse running on the higher Cretaceous layer presents an original fish zone, itself a function of the importance of the distribution and the localisation of the springs feeding the said watercourse.

In conclusion it is proper to insist on the fact that it is important to define with precision the biogeographic territory to which one wishes to apply the rule of gradients. In addition, it is absolutely necessary to first of all carry out a detailed pedo-geological study as well as seasonal thermo-hydrological measurements.

Discussion

Symoens: Does a possible study in the streams of Normandy, of the zoning of invertebrates (except Triclads) show what one observes elsewhere in western Europe, a deviation comparable to that found in the localisation of fish zones?

Arrignon: There exists a neat correlation between physical measurements, chemical analyses and invertebrate samples in the streams of Normandy and more particularly, between populations of invertebrates and fish.

Bontemps: What method have you used to calculate the percentage of fish in the zones of the streams?

Arrignon: The watercourses studied are of dimensions which are suitable for electric fishing surveys. The survey sections, corresponding with various sections of the watercourse, are marked off and isolated by mobile elctric batteries. The populations are caught, and the survey is made by the application of the Petersen method for salmonids and the de Lury method for other fish.

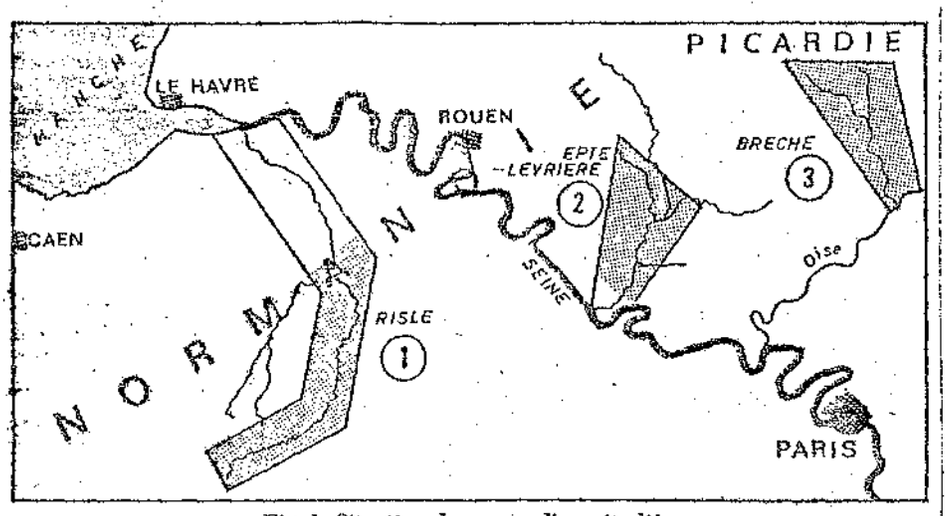

Fig. 1. Situation des cours d'eau étudiés.

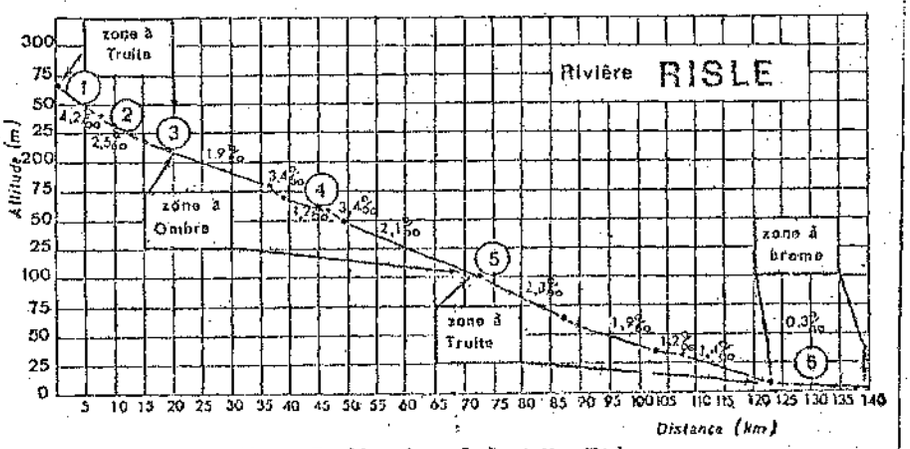

Fig. 2. Profil en long de la rivière Risle.

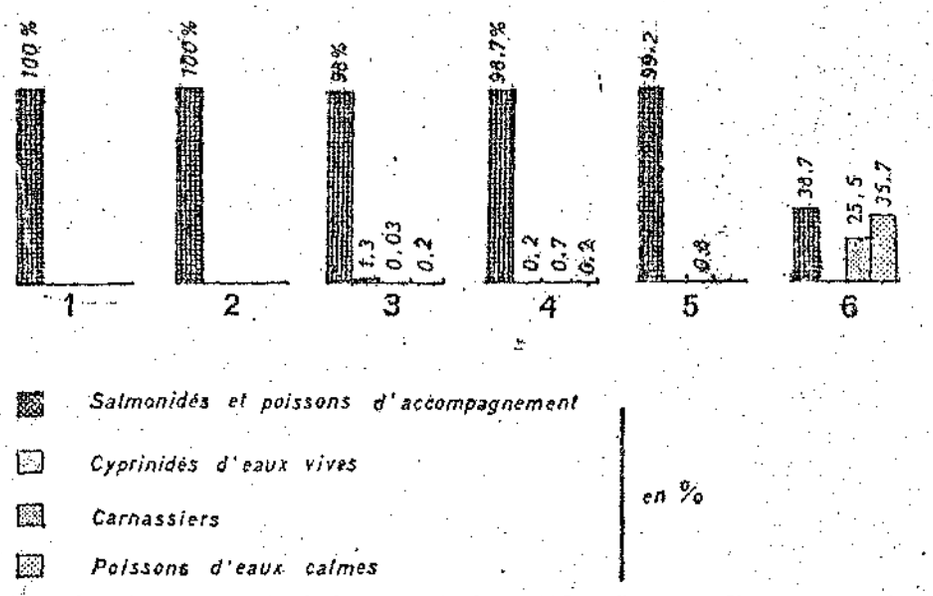

Fig. 3. Population piscicole de la rivière Risle — Echantillonnage effectué par pêche électrique. Pour-cent des captures, en nombres.

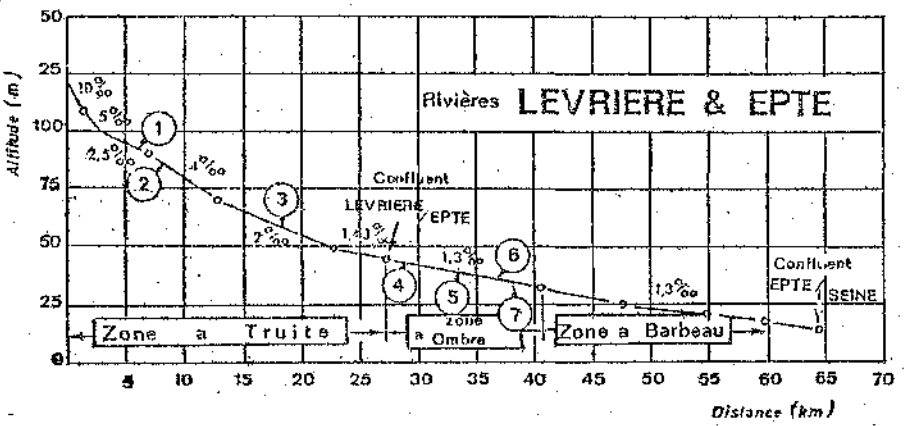

Fig. 4. Profil en long des rivières Levrière et Epte.

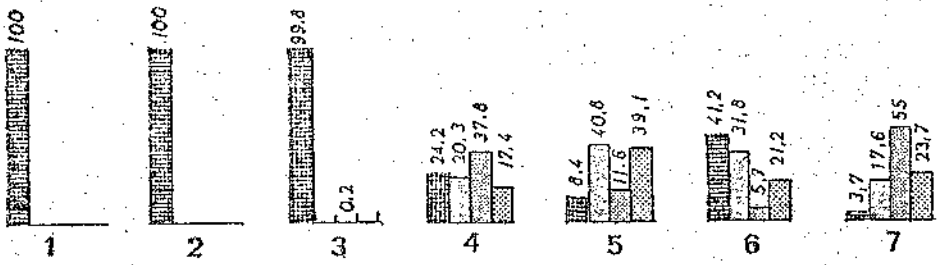

Fig. 5. Population piscicole des rivières Levrière et Epte. Echantillonnage effectué par pêche électrique. Pour-cent des captures, en nombres.

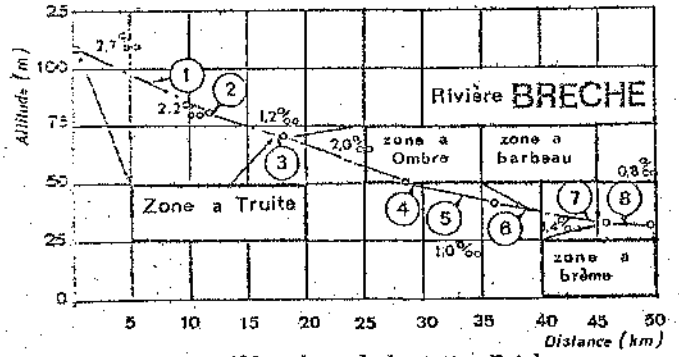

Fig. 6. Profil en long de la rivière Brèche.

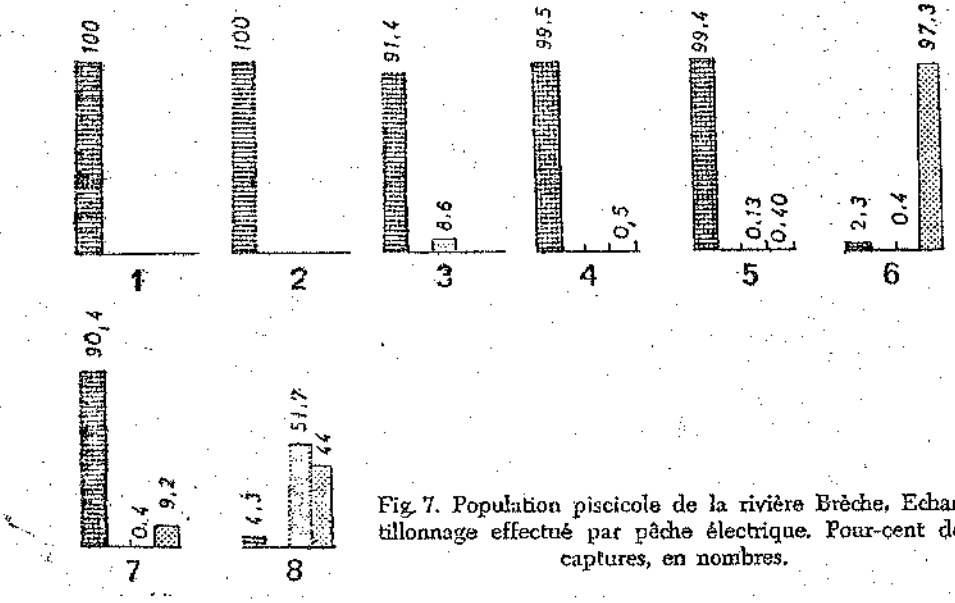

Fig. 7. Population piscicole de la rivière Brèche. Echantillonnage effectué par pêche électrique. Pour-cent des captures, en nombres.

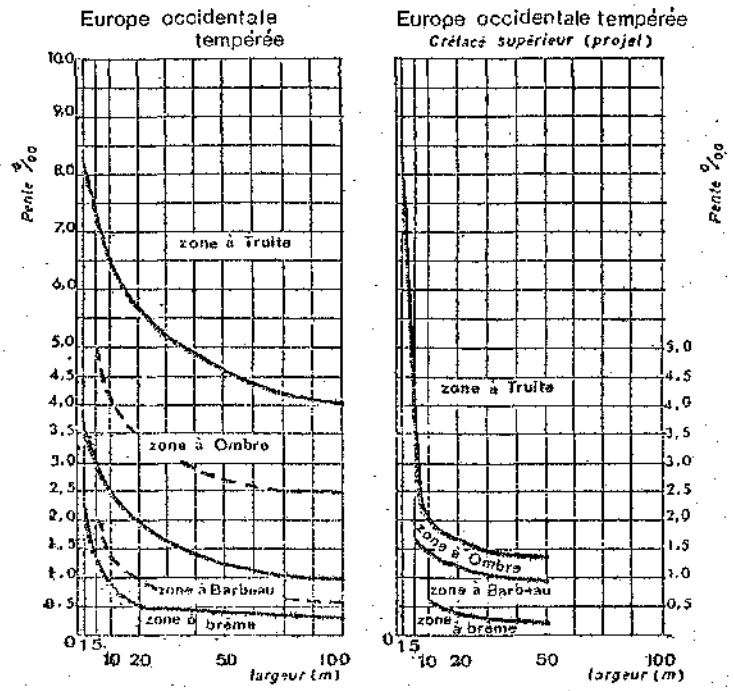

Fig. 8. Graphiques des pentes pour les cours d'eau d'Europe Occidentale tempérée coulant ou non sur le Crétacé supérieur (projet).

Bibliographie

ARRIGNON, J., 1971: Etude hydrobiologique de la Levrière. — Doc. C. S. P., Paris.

— 1970: Aménagement Piscicole des Eaux Intérieures. — S. E. D. E. T. E. C., Paris, 97—98.

ARRIGNON, J. & DE SAUVERZAC, R., 1969: Carte Piscicole de Seine-Maritime. — Ed. C. S. P., Paris, 9—22.

ARRIGNON, J. & LEROY, J., 1971: Etude hydrobiologique de la Brèche. — Doc. C. S. P., Paris.

CUINAT, R., 1963: Diagnose démographique de quelques rivières normandes. — Doc. INRA, Biarritz.

HUET, M., 1946: Note préliminaire sur les relations entre la pente et les populations piscicoles des eaux courantes — Règle des pentes. — *Biolog. Jb. Dodonaea* 13, 232—243.

— 1949: Aperçu des relations entre la pente et les populations piscicoles des eaux courantes. — *Rev. Suisse d'Hydrol.* 11 (3/4), 332—351.

HUET, M., 1962: Influence du courant sur la distribution des poissons dans les eaux courantes. — *Rev. Suisse d'Hydrol.* 24 (2), 411—432.

HUET, M., LELEK, A., LIBOSVARSKY, J. & PENAZ, M., 1969: Contribution à l'identification des zônes piscicoles de quelques cours d'eau Moravie (Tchécoslovaquie). — *Verh. Internat. Verein Limnol.* 17, 1103—1111.

Tab. 1. Peuplement piscicole de la rivière la Risle, d'après inventaire et sondage par pêche électrique

Localité	Secteurs N° 1 Planches	2 Ste Gauburge	3 Aube	4 Rugles	5 Confl. Bave	6 Confl. Corbie
Distance depuis la confluence (km)	145,6	137,5	126,1	105,5	67,8	12,2
Date des observations	26. 8. 69	26. 8. 69	26. 8. 69	27. 8. 69	28. 8. 69	25. 8. 69
Largeur moyenne (m)	1,40	2,50	9	9	10	45
Profondeur moyenne (m)	0,22	0,30	0,75	0,60	0,40	(0,60) 3,00 (1,20)
Pente du tronçon (‰)	4,2	2,5	1,9	3,4	2,6	0,1
Longueur prospectée (m)	200	200	400	200	100	400
Température (°C) (janv. 69)	6°	7°	7°	7°	11°	5°
Débit moyen (l/sec.)	50	215	275	1.825	300	10.580
Ca^{++} (mg/l)	38	54	59	55	93	96
Poissons pêchés						
Salmonidés et Poissons d'accompagnement	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %
Salmo salar	— —	— —	— —	— —	— —	16 6,8
Salmo trutta (m)	— —	— —	— —	— —	— —	33 14
Salmo trutta fario	53 6,8	108 3,94	32 3,1	47 1	334 92,8	42 17,9
Phoxinus phoxinus		600 19,9	1038 40,9	3730 79,7	— —	— —
Cottus gobio	720 90	2206 62,1	740 28	— —	25 6,9	— —
Cobitis barbatula	28 3,4	636 17,9	700 26	845 18	— —	— —
	Total 100	Total 100	Total 98	Total 98,7	Total 99,2	Total 33,7
Cyprinidés d'eau vive						
Leuciscus cephalus			— —	9 0,2		
Leuciscus leuciscus			34 1,3	— —		
Gobio gobio			— —	1 —		
Ecrevisses						
Austropotamobius pallipes pallipes	2					
Carnassiers						
Perca fluviatilis			1 0,03	— —	— —	— —
Anguilla anguilla			— —	36 0,7	3 0,8	52 13,6
Lampetra fluviatilis			— —	— —	— —	28 11,9
						Total 25,5
Autres poissons d'eaux calmes						
Tinca tinca			5 0,2	— —		— —
Rutilus rutilus			— —	10 0,2		— —
Flesus flesus			— —	— —		84 35,7
						Total 35,7

Tab. 2. Peuplement piscicole de l'Epte et de la Levrière, rivière affluente sur la rive droite, d'après inventaire et sondage par pêche électrique.

Localité	Secteurs N° Levrière 1 Martagny amont	2 Martagny aval	3 St Paer	Epte 4 Inval	5 Gisancourt	6 Gueray	7 St Clair
Distance depuis la confluence (km)	62,2	60	47,3	38,7	38	30,5	27,5
Date des observat.	12. 10. 67	12. 10. 67	15. 11. 68	8. 10. 70	8. 10. 70	7. 10. 70	7. 10. 70
Largeur moyenne (m)	3	3	10	15	40	15	15
Profondeur moyenne (m)	0,60	0,75	0,50	(0,60) 1 (1,20)	0,60	(0,80) 1 (1,40)	1,70
Pente du tronçon ‰	5,5	12,5	2	1,3	1,3	1,3	1,3
Longueur prospectée (m)	100	100	200	500	500	500	500
Température (°C)	11	11	8	0,4	6,3	5,9	6
Débit moyen (l/sec.)	270	394	485	3.500	—	—	4.500
Ca^{++} (mg/l)	107	108	112	112	114	115	115
Poissons capturés							
Salmonidés et Poissons d'accompagnement	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %
Salmo trutta fario	216 41	54 39,7	255 54,7	42 24,4	17 7,5	96 40	3 3,7
Salmo trutta trideus	— —	— —	3 0,6	— —	2 0,9	— —	— —
Thymallus thymallus	— —	— —	— —	— —	— —	3 1,2	— —
Phoxinus phoxinus	— —	— —	— —	— —	— —	— —	— —
Cottus gobio	311 59	47 34,5	200 42,9	— —	— —	— —	— —
Cobitis barbatula	— —	35 25,8	7 1,5	— —	— —	— —	— —
	Total 100	Total 100	Total 99,8	Total 24,4	Total 8,4	Total 41,2	Total 3,7
Cyprinidés d'eaux vives							
Barbus barbus				— —	41 18,2	50 20,4	7 8,6
Leuciscus cephalus				35 20,3	41 18,2	28 11,4	7 8,8
Gobio gobio				— —	10 4,4	— —	— —
				Total 20,3	Total 40,8	Total 31,8	Total 17,6
Carnassiers							
Esox lucius			— —	6 3,5	2 0,9	— —	2 2,5
Perca fluviatilis			— —	5 2,9	2 0,9	2 0,8	— —
Anguilla anguilla			1 0,2	54 31,4	22 9,8	12 4,9	42 52,5
			Total 0,2	Total 37,8	Total 11,6	Total 5,7	Total 55
Cyprinidés et autres poissons d'eaux calmes							
Rutilus rutilus				30 17,4	88 39,1	52 21,2	18 22,5
Cyprinus carpio				— —	— —	— —	1 1,2
				Total 17,4	Total 39,1	Total 21,2	Total 23,7

Tab. 3. Peuplement piscicole de la rivière la Drôme, d'après inventaire et sondage par pêche électrique.

	Secteurs N°							
	1 Colseaux	2 Bulles	3 Lilz	4 Clermont	5 Séravenne	6 St Gobain	7 Lalgueville (bras)	8 Villers (bras)
Distance depuis la confluence (km)	40,1	34,0	30	19,8	16,8	12	7,5	4
Date des observations	20. 10. 70	20. 10. 70	20. 10. 70	20. 10. 70	21. 10. 70	21. 10. 70	22. 10. 70	22. 10. 70
Largeur moyenne (m)	2,10	4,50	4,60	4,80	7	7,70	7,50	7,50
Profondeur moyenne (m)	0,35	0,70	0,45	0,50	0,55	1	0,85	0,85
Pente du tronçon (‰)	2,9	2,2	1,2	2	1	1,4	0,8	0,8
Longueur prospectée (m)	100	155	200	100	120	200	100	100
Température (°C) (janv.)	10	10	9,6	8,6	8	8,2	6	6
Débit moyen (l/sec)	255	664	702	1.846	1.648	2.048	1.909	1.685
Ca^{++} (mg/l)	112	113	108	168	108	110	108	108
	(Nombres à l'hectare)							
Poissons pêchés								
Salmonidés et Poissons d'accompagnement	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %	Nbre %
Salmo trutta fario	6408 98,85	2098 38,1	228 15	804 2,8	5451 61,5	— —	80 0,4	— —
Salmo trutta irideus	— —	997 18,6	— —	— —	— —	— —	— —	— —
Phoxinus phoxinus								
Cottus gobio	74 1,15	2270 42,3	1164 76,4	27555 96,7	3366 37,9	213 2,3	16174 90	227 4,3
Cobitis barbatula								
	Total 100	Total 100	Total 91,4	Total 99,5	Total 99,4	Total 2,3	Total 90,4	Total 4,3
Cyprinidés d'eaux vives								
Cobio gobio								
Carnassiers								
Perca fluviatilis								
Esox lucius			131 8,6		12 0,13	40 0,4	81 0,4	2755 51,7
Anguilla anguilla								
Lota lota								
			Total 8,6		Total 0,13	Total 0,4	Total 0,4	Total 51,7
Autres poissons d'eaux calmes								
Cyprinus carpio								
Carassius carassius				131 0,5	36 0,40	9058 97,3	1637 9,2	2342 44
Rutilus rutilus								
Tinca tinca								
				Total 0,5	Total 0,40	Total 97,3	Total 9,2	Total 44

Notice

Please note that these translations were produced to assist the scientific staff of the FBA (Freshwater Biological Association) in their research. These translations were done by scientific staff with relevant language skills and not by professional translators.